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Proceedings of the 2013 Zonal Assessment of Northern and Striped Shrimp (Shrimp Fishing Areas 2-6)

February 18-20, 2013
St. John's, Newfoundland and Labrador

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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

A Zonal Advisory Process (ZAP) was held in St. John's, Newfoundland February 18-20, 2013. The purpose of the meeting was to assess Northern Shrimp (*Pandalus borealis*) in Shrimp Fishing Areas (SFAs) 4 to 6 (NAFO Divisions 2G to 3K), and both Northern Shrimp and Striped Shrimp (*Pandalus montagui*) in the Eastern and Western Assessment Zones (SFAs 2 and 3). The assessment included development of Precautionary Approach Framework reference points for both species in SFA 3. In addition, participants discussed the risks and benefits of using a two-year average of female spawning stock biomass index to smooth the year-to-year variability for the purpose of making management decisions.

Meeting participants were from Fisheries and Oceans Canada (DFO) Science and Resource Management from Newfoundland and Labrador, Central and Arctic, and National Capital regions, the governments of Nunavut, Nunatsiavut, and Newfoundland and Labrador, Nunavut Wildlife Management Board, Makivik Corporation, Nunavut Tunngavik Inc., Torngat Wildlife, Plants, and Fisheries Secretariat, and the shrimp fishing industry.

This Proceedings report summarizes the relevant discussions and presents the key conclusions reached at the meetings. In additional two science advisory reports (SARs) and two research documents resulting from the meeting, one from each region, will published on the DFO Canadian Science Advisory Secretariat Website.

Compte rendu de l'évaluation zonale de la crevette nordique et de la crevette ésope pour 2013 (zones de pêche à la crevette 2 à 6)

SOMMAIRE

Un processus d'évaluation zonale (PEZ) a eu lieu à St. John's, à Terre-Neuve-et-Labrador, du 18 au 20 février 2013. La réunion avait pour objet d'évaluer la crevette nordique (*Pandalus borealis*) dans les zones de pêche de la crevette (ZPC) 4 et 6 (divisions 2G à 3K de l'Organisation des pêches de l'Atlantique Nord-Ouest), ainsi que la crevette nordique et la crevette ésope (*Pandalus montagui*) dans les zones d'évaluation est et ouest (ZPC 2 et 3). L'évaluation comprenait l'élaboration de points de référence pour le Cadre de l'approche de précaution pour les deux espèces dans la ZPC 3. En outre, les participants ont discuté des risques et avantages d'utiliser une moyenne de l'indice de biomasse du stock reproducteur femelle sur deux ans pour diminuer la variabilité d'une année à l'autre en vue de prendre des décisions en matière de gestion.

Les participants à la réunion provenaient des organismes suivants : le Secteur des sciences et le groupe Gestion des ressources de Pêches et Océans Canada (régions de Terre-Neuve-et-Labrador, du Centre et de l'Arctique ainsi que de la capitale nationale); les gouvernements du Nunavut, du Nunatsiavut, et de Terre-Neuve-et-Labrador; le Conseil de gestion des ressources fauniques du Nunavut; la Société Makivik; Nunavut Tunngavik Inc.; le Torngat Wildlife, Plants, and Fisheries Secretariat; et l'industrie de la pêche à la crevette.

Le présent compte rendu résume les discussions pertinentes et présente les conclusions importantes tirées de la réunion. Par ailleurs, deux avis scientifiques (AS) et deux documents de recherche issus de la réunion (l'un de chaque région) seront publiés sur le site Web du Secrétariat canadien de consultation scientifique de Pêches et Océans Canada.

INTRODUCTION

Fisheries and Oceans Canada (DFO) Science was asked by DFO Resource Management to provide advice on stock status and sustainable harvest levels of Northern Shrimp (Pandalus borealis) and Striped Shrimp (Pandalus montagui)for the 2013/2014 fishing season in Shrimp Fishing Areas (SFAs) 2-6. The advice will be used to establish Total Allowable Catches (TACs).

DFO Science held a Zonal Advisory Process (ZAP) February 18-20, 2013 in St. John's, Newfoundland. The purpose of these meetings, as described in the Terms of Reference (ToR; Appendix 1), was to provide advice to DFO Resource Management on the status of Northern Shrimp in SFAs 4 to 6, and both Northern Shrimp and Striped Shrimp in the Eastern and Western Assessment Zones (SFAs 2 and 3). The assessment included development of reference points for the Precautionary Approach Framework for both species in SFA 3. In addition, participants discussed the risks and benefits of using a two-year average of female spawning stock biomass index to smooth the year-to-year variability for the purpose of making management decisions.

Meeting participants (Appendix 2) were from Fisheries and Oceans Canada (DFO) Science and Resource Management from Newfoundland and Labrador, Central and Arctic, and National Capital regions, the Governments of Nunavut, Nunatsiavut, and Newfoundland and Labrador, Nunavut Wildlife Management Board, Makivik Corporation, Nunavut Tunngavik Inc., Torngat Wildlife, Plants, and Fisheries Secretariat, and the shrimp fishing industry.

After a round of introductions, the Chair provided a brief introduction to the meeting, and reviewed the agenda (Appendix 2). The meeting began with presentations on environmental conditions and ecosystem factors, followed by the assessment of shrimp beginning with SFA 6, SFA5, SFA4 and then the Eastern and Western Assessment Zones.

PRESENTATIONS AND DISCUSSIONS

AN ASSESSMENT OF THE PHYSICAL OCEANOGRAPHIC ENVIRONMENT IN NORTHWEST ATLANTIC, UPDATE FOR 2012

Authors: E. Colbourne, J. Craig, C. Fitzpatrick, D. Senciall, P. Stead and W. Bailey

Presenter: E. Colbourne

- The North Atlantic Oscillation index (NAO), a key indicator of climate conditions on the Newfoundland and Labrador Shelf, increased to 1.3 standard deviations above normal in 2012, the highest since 1989.
- This resulted in an increase in winter cooling of the water column in northern areas that was advected southward during the year resulting in a significant decrease in ocean temperatures compared to 2011.
- Annual water column averaged temperatures off St. John's (Station 27) decreased to 1 standard deviation (0.4 °C) above normal from the record high of 3 (1 °C) in 2011.
- During the fall, bottom temperatures in Div. 2J, Div. 3K and Div. 3LNO decreased from 2, 2.7 and 1.8 standard deviations above normal in 2011 to 1.1, 1.2 and 0.2 above normal in 2012, respectively.
- The area of the bottom covered by water in the 2-4 °C range (the most common temperature range for northern shrimp) in the Div. 2J3K region decreased in 2012 compared to the previous two years.

OCEAN PRODUCTIVITY TRENDS ON THE NEWFOUNDLAND AND LABRADOR SHELVES

Authors: G. Maillet, P. Pepin and E. Colbourne

Presenter: G. Maillet

- Indices of primary and secondary production have remained relatively stable over the past decade and in some cases have trended upwards (e.g., copepod abundance) that may support feeding of early life stages (larval and juvenile) along with adult northern shrimp.
- The peak timing of the spring bloom based on satellite imagery is generally advancing in recent years and is shorter in duration which may influence the temporal availability of prey to secondary producers and higher trophic levels.

General Discussion

In the presentation, the authors inferred that large copepods are increasing. There was a distinct shift from 2002-2006 then a dramatic downturn for the < 1000 micron fraction. The larger, > 1000 fraction showed the reverse. A participant asked if any other components are increasing. The presenter indicated it is a qualitative assessment of what is in the fractions and more detailed analysis is required. There is some indication of shifts to smaller species of copepods. When asked if there are changes in phytoplankton and zooplankton relationships they indicated there was a weak correlation between phytoplankton increases and zooplankton increases but further analysis is required to make causal statements in regard to this.

EXPLORATORY ANALYSIS OF RECENT CLIMATE EFFECTS ON NORTHERN SHRIMP (SFA 6)

Authors: E. Colbourne, D. Orr and G. Maillet

Presenter: E. Colbourne

- Analyses show that 84 % of fishable catch of shrimp during the fall surveys are associated with relatively warm Labrador slope water in the 2-4 °C range.
- Both the catch per unit effort (CPUE) and fishable biomass were shown to be positively correlated with temperature indices and negatively correlated with sea ice, cold intermediate layer (CIL) and the NAO index.
- Strong correlations between the CPUE and the environment during the same year (0-Lag) indicate that climate conditions affect the performance of the fishery.
- Positive correlations between temperature indices with the fishable biomass/CPUE and the timing of the annual production cycle indicate an effect on early life stages of shrimp in some areas.

General Discussion

Participants discussed whether ocean warming is good for shrimp. The temperature limit for shrimp is probably not yet reached in SFA6. The presenter was asked to elaborate on the strong correlation at 0-lag. CPUE is lower when sea ice is abundant. There was some discussion that larval survival depends on phytoplankton so if good phytoplankton blooms occur the right time you should expect a positive response four years later when the shrimp enter the fishery. The presenter was asked if there were delayed blooms on the Labrador Shelf and earlier blooms on the Grand Banks. Off Labrador there is declining overall productivity and timing is delayed. On the Newfoundland shelf productivity is increasing and timing is advancing.

This is contrary to what the fishing industry is seeing with decline in the south and stable in the north. It seems to match more with the timing of blooms.

UPDATE ON TRENDS IN THE FISH COMMUNITY AND DIET OF KEY GROUNDFISH SPECIES IN THE NEWFOUNDLAND-LABRADOR ECOSYSTEM

Authors: M. Koen-Alonso, F. Mowbray, P. Pepin, N. Wells, D. Holloway, and B. Vaters

Presented by M. Koen- Alonso

- During the late 1980s and early 1990s most of the fish community in the Newfoundland and Labrador marine ecosystem collapsed; during this time shrimp biomass increased significantly.
- In recent years (~2004-2007) some fish species increased from their mid-1990s very low level; but most increases have stalled after 2007. Current levels are still well below pre-collapse ones. Shrimp has declined significantly since 2007; its current biomass level in the Southern Labrador-Northern Newfoundland Shelf (Div. 2J3KL) is similar to the one observed in 1995-1997.
- In the mid 1990s, shrimp became an important prey for several key groundfish species. However, shrimp dominance in the diets seems to be in decline, tracking the relative availability of shrimp in the ecosystem. In 2011, there was a decrease in the contribution of shrimp to the diet of Atlantic Cod (*Gadus morhua*), Greenland Halibut (*Reinhardtius hippoglossoides*), and American Plaice (*Hippoglossoides platessoides*). The reduction of shrimp in the diet seems to be more important in the southern areas. Despite these changes, shrimp continues to be an important forage species.

General Discussion

The presenter suggested early in the presentation that the decline of shrimp has more to do with fishing than the environment. A participant indicated that we have not been able to detect the effect of shrimp fishing on biomass so wondered how they had come to that conclusion. The presenter was also asked if predator increases had any effect on shrimp. The presenter indicated that fishing impacts the trajectory of the five groundfish species. By-catch of groundfish in the shrimp fishery, for example, does not appear to have an effect. The impact of fishing is still an overall driver. Based on diet composition, the level of biomass of fish now versus what we used to have, combined with trend of reduction of shrimp in diet tends to suggest that predation may be a contributing factor but it is not likely a driver. Seal predation was questioned. The presenter indicated that the models include seal predation though the data do not indicate a significant effect on shrimp biomass. Marine mammals represent a portion of predation, but are not thought to be dominant species. Historically the system was able to sustain large stocks of fishes and marine mammals at one time. Competition however has not been addressed.

AVERAGING OF SHRIMP FEMALE SPAWNING STOCK BIOMASS (SSB) INDEX OVER MULTIPLE ASSESSMENT YEARS

Author and Presenter: G. Evans

A specific term of reference for the meeting was to address the following:

In the context of the Precautionary Approach, advise on the risks and benefits of using a two-year average of spawning stock biomass (SSB), as well as the risks and benefits of using a single year approach to determine the stock status zone. Are there any other methods that

could be used to smooth the year-to-year variability? If so, explain the advantages and disadvantages of each method.

The participants discussed this issue on a number of occasions during the meeting, carefully considered what the questions were that were be asked and how best to address them. The discussion evolved along with this consideration of the questions resulting in the text in Appendix 4. The text was not being added to either Science Advisory Report dealing with this but instead a separate memo with the response would be sent directly to the relevant DFO managers.

AN ASSESSMENT OF DIVISIONS 2G-3K NORTHERN SHRIMP (*PANDALUS BOREALIS*) IN 2013

Authors: D. Orr and D. Sullivan

Presenter: D. Orr

Abstract

The February 2013 Northern Shrimp (*Pandalus borealis*) assessment was performed for NAFO Div. 2G, Hopedale + Cartwright Channels as well as Hawke Channel + Div. 3K, which correspond to SFAs 4, 5, and 6, respectively. Status of the resource in each area was inferred, in part, by examining trends in commercial catch, effort, CPUE, fishing pattern and size/sex/age composition of the catches. Fisheries independent data were obtained from annual autumn multispecies research bottom trawl surveys into SFAs 5 and 6 (1996-2012), as well as, summer Northern Shrimp Research Foundation (NSRF) - DFO shrimp based bottom trawl research surveys into SFA 4 (2005–2012). These surveys provide information on distribution, abundance, biomass, size/ sex composition and age structure of shrimp.

Catches increased from 22,000 t in 1994 to over 115,000 t by 2004-2005 due mainly to increases in the TAC. The overall 2004/2005 TAC was set at 111,552 t and maintained until 2008/2009 when it was increased to 120,344 t. This TAC was maintained through to 2009/2010; however, due to operational and commercial constraints, it was not taken. Under the Integrated Fisheries Management Plan (IFMP) Precautionary Approach (PA) framework the SFA 6 TAC decreased by 39 % to 52,387 t by 2012/2013 due to resource status declines within SFA 6, resulting in an overall TAC of 87,007 t for that year. Resource status in SFA 6 improved in 2011, therefore, the 2012/2013 SFA 6 TAC was increased to 60,245 t; resource indices remained high in SFA 4 therefore the TAC in SFA 4 was increased to 13,018 t resulting in an overall TAC of 96,563 t for the 2012/2013 management year. It was anticipated that this TAC will be taken by March 31, 2013.

The SFA 6 large vessel CPUE increased between 1989 and 1997 and oscillated at a high level until 2006/2007, thereafter it declined until 2009/2010 but has since been increasing. The small vessel CPUE showed a similar pattern. The SFA 5 large vessel CPUE increased from 1992 to 2001 and has oscillated around this higher level since then. Several factors including resource management decisions, market conditions, searching, and distribution of Striped Shrimp relative to Northern Shrimp, influenced SFA 4 large vessel CPUE bringing into question its use as a fishery performance indicator. Therefore SFA 4 large vessel CPUE is not discussed within the body of this report.

The resource decreased from a peak in 2006 to near 1996 levels in the south (SFA 6); remained near average on the mid Labrador Shelf (SFA 5) and increased in the north (SFA 4).

The SFA 5 fishable biomass index increased from around 90,000 t in 1996-1999 to 184,000 t in 2001 and has since been approximately 150,000 t with the 2012 estimate at 147,000 t. Female

SSB index increased from 40,000 t in the 1996-1999 period to 96,000 t in 2001 but has since decreased with the 2012 estimate at 63,000 t.

The SFA 5 exploitation rate has varied without trend around 15 % over most of the time series. Annual female total mortality oscillated between about 35-75 % over the period 1998 – 2011 averaging about 60 %. Research survey SSB was assessed to be in the Healthy Zone within the IFMP PA Framework. The 2012/2013 exploitation rate is expected to be about 16 %. If the 23,300 t TAC is maintained through 2013/2014 and taken then the SFA 5 exploitation rate will remain at 16 %.

The SFA 4 fishable biomass index increased from 62,000 t in 2005 to 180,000 t by 2009, decreased to 127,000 t in the next year before increasing to 191,000 t in 2012. Similarly, the female SSB index increased from 35,000 t in 2005 to 140,000 t by 2009, decreased to 71,000 t in 2010 then increased to 110,000 t in 2012. Annual female total mortality oscillated between about 40-50 % over the period 1999 – 2008. Due to high numbers of ovigerous females, no estimates available since then. Exploitation rate, within SFA 4, has been between 6 % and 9 % since 2007/2008 and the current estimate is 7 %. Research survey SSB was assessed to be in the Healthy Zone, within the IFMP PA Framework, and it is anticipated that the 2012/2013 exploitation rate will be less than 10 %.

SFA6 Shrimp Stock General Discussion

It is currently estimated that 51,000 t of the 60,000 t TAC has been taken so far in the 2012/2013 fishing season. The meeting noted that the original large-vessel catch should be standardized to June, not March, and that this would be updated in the research document and SAR.

Catch data indicated that the fishery is not concentrating on single specific cohorts but multiple cohorts at any given time. It was also noted that ovigerous females may be moving up towards cooler waters in the spring, and that the clustering of the resource can lead to lower catch rates.

Figure 21 showed that temperature warmed between 1996 and 2011 but then cooled again in 2012. However, it was not possible to determine whether temperature was important in determining shrimp distribution as temperature is highly correlated with depth.

The presenter clarified that tables with stratified analysis of commercial catch data (e.g., Table 9 in the research document) display both biomass contractions as well as spatial contraction of the fishery. A comment was made that it appears to be deep strata that are decreasing the most over time.

Participants pointed out a disconnect between fishery and survey data. The fishery shows increased CPUE. There was some thought that it could result from an environmental or economic driver. The presenter noted that CPUE data in the index strata tracks the survey data well for this time series. Fishable biomass (all females and males >17 mm carapace length) and female spawning stock biomass (all females) are the indices used in determining stock status. Fishable biomass and SSB tended to track one another in the time series, with 2012 estimates near the lowest in either time series.

Participants discussed the recruitment index presented. Modal analysis of recruitment can be used to predict abundances at age for the first three years, with a very weak relationship afterward. The presenter attempted to evaluate whether recruitment, number of 11.5 mm to 17 mm shrimp, could be used to predict future abundance using appropriate lags. However the signal is insufficient to be used as a prediction of future biomass; it is a measure of current status. Participants questioned the usefulness of the recruitment index as DFO has never been able to successfully demonstrate a relationship between recruitment and fishable biomass. Co-variables could potentially be used in the future for predictive purposes. A suggestion was made

for a research request to further investigate the relationship between the recruitment index and fishable biomass in subsequent years. It was noted that this has been attempted in the past with NAFO shrimp stocks, however momentum was not maintained. Looking at a climate index simultaneously may prove valuable. Part of the issue is that the Campelen trawl does not sample recruitment fully and the signal is worse going further north.

Mortality between age 4+ and 5+ males and females, and between multiparous females and total females was determined using a four year running average. It doesn't estimate mortality for individuals under 4 years of age. Mortality is estimated at approximately 50 %.

In the PA Framework, the current biomass estimate falls with the cautionary zone of the PA framework at 187,000 t. If the current TAC of 60,000 t is maintained the exploitation rate will be 19 % - the third highest in the time series. Questions arose about whether any target exploitation rates had been set for the PA framework. These targets have not yet been agreed to by the PA working group.

Fishery data were evaluated using catch, CPUE, and distribution of fishing effort.

The presenter was asked if the large vessel data (Figure 9 in the research document) were from index strata or all strata. He indicated it was index strata. Some of the plots indicate that 2011 was a high catch year although the fishery in 2011 would not have been considered a bumper year. There are concerns about using data from January to May for this analysis, however it is done this way to avoid using data during shrimp migration periods. A participant requested that DFO make a comparison of stratified CPUE data and raw CPUE estimates. The presenter was asked to plot the time series of Table 9 with fishable biomass.

This led to a discussion about the validity of using CPUE data for science advice, given that these numbers could potentially increase even when the resource is contracting. There should be a test of CPUE data against survey predictions from the year before, as fishermen are concerned that only survey data are used. Economics factor drive the fishery. CPUE provides data to assess fishery performance. There were several suggestions for plots to evaluate consistency between survey and fishery data in strata.

Scientists stated that CPUE is not a valid indicator of stock status, and it was noted that fishermen should have access to information about the data collected on surveys, including methods, gear type, and weather conditions. It was noted that summary documents are available for the surveys, however it may be useful to make more complete information available. It was also clarified that many precautions are taken to ensure that the data collected is of high quality (for example using Scanmar sensors), and that survey conditions are taken into account when analysing data and providing scientific advice.

Figure 24 (indices of spatial distribution) was discussed and a question was asked about whether the resource contraction (proportion of sets with zero density) was significant – it was then pointed out that no sound conclusions can be drawn. The fishing industry does not see it as a cause for major concern as catches were taken in more diverse areas, especially for the small vessel fleet. A suggestion was made to refer to the numbers without specifically mentioning contraction. It was suggested that fishermen chose to fish in specific areas because of economics.

Concerns about including double trawl data in the models were raised. It was clarified later that the models account for the use of single and double trawls.

The issue of the use of the word 'contraction' when referring to the SFA6 stock was again raised during the bullet discussion, as CPUE data did not clearly reflect this. It was clarified that the contraction refers not to the fishery itself but to the actual biomass estimated from the research survey data. Further clarification on the issue of contraction was offered, with the CPUE data

from 2012 showing a marked concentration of fishing effort, namely that 95 % of the catch is now concentrated in only 63 % of the area. In light of this the word concentration was agreed to be more appropriate than contraction. The meeting participants agreed that prior to 'ringing alarm bells', the implications of doing so would need to be further deliberated.

The group then moved on to a comparison of large vessel biomass data with survey fishable biomass, large vessel CPUE and the index strata. Although some peaks and troughs coincided, linear regressions had weak fits when comparing each separately. This analysis was also completed with a one-year lag with similar results. It was clarified here that the large vessel biomass is based on CPUE data.

The discussion then returned to the validity of using CPUE as a reliable estimate of stock biomass. It was noted that large vessel CPUE has not been used because of very low coverage of the SFA. The group was reminded that fishers are not in the business of obtaining an unbiased estimate of biomass, but to catch fish. In light of various concerns with interpretation of CPUE data, the meeting agreed that CPUE would not be used as a measure of stock biomass, but rather as a measure of fishery performance for SFA 5 and SFA 6.

A concern was raised with regards to the long-term averages used in many of the figures for the assessments, noting that the shrimp fishing industry in this and other SFAs went through a period of building up in the 1990s and became more stable since then. This was visually evident in most cases.

A suggestion was offered to restrict all analyses to the 200-400 metre zone, which shrimp are known to prefer over other depth strata.

The discussion then turned to the recruitment index. Although recruitment should give a general indication of resource potential, strong relationships have been hard to come by in this area. Survey data for areas off of Greenland were mentioned, noting that the fishable biomass there matched nicely with the recruitment index.

The group was reminded that one peak in recruitment will not necessarily translate into greater fishable biomass, as multiple year classes are fished at any given time. The bulk of fishable biomass is made up of 4 and 5-year olds, with some shrimp surviving to 6 years of age.

A bullet discussing mortality rate was then discussed, with the data suggesting a total annual mortality rate of age 4+ animals of approximately 50 %.

The group was curious as to what a 'safe' level of mortality would look like. The literature does not typically address the issue without context and a broad range has been observed. It is not clear how comparable mortality indices are between different stocks.

A suggestion was made to also include an exploitation rate index in mortality analyses.

A bullet was drafted to address research survey SSB, the TAC and the exploitation rate within the PA framework. It was suggested that an options table be provided for exploitation rates, including lower levels given that the stock is estimated to be in the cautious zone. It was noted that a removal reference has not yet been adopted by the PA working groups. Concerns about providing a table were raised given the incomplete state of the PA and the upcoming Northern Shrimp Advisory Committee (NSAC) meeting.

Participants agreed with the final summary bullets for SFA6 included in the SAR.

SFA5 Shrimp Stock General Discussion

Catches of shrimp in this area have increased from a level of approximately 15,000 t in the late 1990s and early 2000s to 23,000 t since then. The fishery operates largely in winter and spring, with very little fishing effort from small vessels.

Biomass and abundance increased after 1999 and have remained high since. There is no indication of a spatial contraction of the fishery in this SFA. SSB is estimated to be in the healthy zone, and an exploitation rate of 16 % will have occurred if the entire TAC is taken.

CPUE should be described as fluctuating around the long-term mean. Stratum 957 (Table 34) seemed to be an anomaly as it has only ever been fished twice yet had the highest biomass. It was the most northerly stratum in Div. 2H. The author was asked to check the area.

Participants felt the full TAC should be shown as the last point in the PA figure without the open triangle. Small vessel quota is transferred offshore so the full TAC has probably been taken. Bridging is quota carry-over, usually it is carry forward although this year we are likely to see carry back. Updating to the full TAC for this year should be done in the exploitation rate and PA figures for all SFAs.

Many of the same issues arose for the presentation of the SFA5 assessment data as for SFA6, and thus discussion was limited to brief clarifications for several of the figures.

Participants agreed with the final summary bullets for SFA5 included in the SAR.

SFA4 Shrimp Stock General Discussion

The SFA4 shrimp stock is mainly exploited by large vessels, mainly during the summer and fall. Evidence suggests a spatial shift in recent years, with an expansion of effort to broader areas. In addition, Striped Shrimp have been on the rise in the area, with significant (possibly directed) catches occurring in recent years. Fishers are opportunistic and will not likely move when they get catches of *P. montagui* as they once would have done given the similar prices obtained from either species. Management rules within the shrimp fishery state that when two species are caught, the species that makes up greater than 50 % of the catch is the one which the catch is directed toward. It was noted that a significant amount of sets are directed toward *P. montagui* and that this may affect the performance of the P. borealis fishery. Concern was also raised that this may confound the statistics performed in the CPUE analysis. Therefore it was agreed that CPUE would not be included in the SAR.

Although DFO Science has not formally assessed *P. montagui* in the area to date, management may request this in the near future.

Participants suggested the fishery had phenomenal success in the south with more vessels getting maximum volume of reasonable size shrimp so they fished south rather than waiting for the north to come through. Participants also suggested that the allocation of effort between the two species is affecting the analysis of fishery performance in the north. The presenter was asked to remove the northern area from the analysis to remove the two species issue. It was suggested that the SAR note some of the issues and difficulties with these data.

The current fishable biomass for P. borealis is 191,400 t and the SSB is 110,000 t. These levels are approximately 50 % greater than 2010 levels. The exploitation rate has remained between 6 % and 10 % since the 2006-07 management year.

Another possible confounding factor for this year's data is that a new vessel was used for the survey in 2012. The presenter suggested that this may have been a factor in the high biomass. In planning for a new vessel, the approach was to use the same gear and follow the same protocols. The same crew was running both vessels. The only physical difference identified between the two ships and the gear used was warp size. The Aqviq warp was half the diameter of that on the Ballard. A participant asked if anyone had looked at performance statistics from the survey. A comparison was made of the door spread, wing spread and warp ratio. It was discovered there was a shorter warp ratio used in the 2012 survey. This does not follow what is described in the standard fishing protocol. However, tows are standardized by measured

wingspread and therefore any differences in wingspread are accounted for in the standardization. A participant was concerned by the discussion of vessel effects as it was felt that assurances had been made that there would be no problems with the data resulting from the change in vessel.

Participants reached the same conclusion about recruitment for this SFA. There was a great deal of annual variability in the recruitment index, and the signal could not be followed as a response in fishable biomass through subsequent years.

Annual female total mortality oscillated between about 40-50 % over the period 1999–2008. It was not possible to estimate mortality rates after 2008 due to high numbers of ovigerous females in the observer samples. The method used is dependent upon distinguishing between primiparous and multiparous females. However, this becomes impossible once the females become ovigerous.

There was some discussion of the low exploitation rate compared to other areas. It was pointed out that there was no strategy to keep the exploitation rate low.

Participants agreed with the final summary bullets for SFA4 included in the SAR.

ASSESSMENT OF NORTHERN SHRIMP (*PANDALUS BOREALIS*) AND STRIPED SHRIMP (*PANDALUS MONTAGUI*) IN THE EASTERN AND WESTERN ASSESSMENT ZONES (SFA 2 AND 3)

Author and Presenter: T. Siferd

Abstract

Northern and Striped Shrimp were assessed within the Eastern and Western Assessment Zones (EAZ/WAZ) which overlays SFAs 2 and 3. Surveys conducted annually by the NSRF in the EAZ since 2006 provided the fishery independent data for the assessment of the EAZ. No new survey information was available since the 2012 monitoring update but the information there was pulled forward for the purpose of setting reference points in the WAZ.

In the EAZ, P. borealis catches have been fluctuating at about 6,000 t from 1997 to 2009/2010 but increased above this level in 2011-12 but likely to be below in 2012/2013. Fishable biomass and female spawning stock biomass have averaged about 68,000 t and 40,000 t respectively for the period 2008-12. Fishable biomass for 2012 however was below average at 60,000 t while female spawning stock biomass was slightly above at 41,000 t. The resource was shown to remain in the Healthy Zone of the PA framework in 2012.

P. montagui catch in the EAZ had decreased from about 4,000 t in 1999 to a low of 135 t in 2011. Catch for 2012 have increased to 656 t mainly because of renewed effort with the Nunavik Marine Region. Both fishable and female spawning stock biomasses increased significantly in 2012 with almost all the increase coming in the Resolution Island Study Area – West (RISA-W) area. This increase is only possible through an influx of shrimp to the EAZ and not local production. This increase moved the resource from the Cautious Zone of the PA framework well into the Health Zone in 2012.

Reference points were developed for the WAZ based the survey biomass estimates available and the same proxies used for the EAZ. The Upper Stock Reference (USR) was set at 3,400 t and Limit Reference Point (LPR) at 1,300 t for P. borealis. For *P. montagui* the USR is 18,000 t and LPR is 6,700 t. Based on these new reference points, both resources were in the Healthy Zone of the PA framework in 2011.

Temperature regime in the EAZ has moderated from the highs of 2010 and 2011 down to the levels seen during the first four years of the survey. The lower temperature more conducive to *P. montagui* may have contributed to its return to the EAZ in 2012.

General Discussion

There are similar concerns with regard to recruitment in these areas as in southern SFAs. Few small shrimp are caught in the codend. Linney bag data are only used for plotting – not for any modeling purposes. Linney bag catches are higher in these areas than in the SFAs further south which may be a function of density. Similar changes in recruitment over the years occurred for both species. Participants asked if Figure 19 could be changed to have similar scales.

Concerns arose again with the very large increase in biomass this year. Caution was suggested in case this is a year effect. One large set can create very large confidence intervals. A tripling of biomass is not possible through biological production, and thus participants suspected that migration in from other areas may have occurred. There may have been a migration of shrimp from the WAZ; however, numbers for the two areas cannot be compared because of the absence of survey data for the Western Zone this year. It was suggested that the influx came from SFA 4 although the net current goes from SFA 3 to SFA 4. Shrimp are likely highly mobile in the area due to oceanographic currents. As a result of the possible migration there may be concerns around double-counting in the two zones. Treating the east and west as a single management unit may resolve the issue. It was noted that similar issues exist around the boundaries of all management zones.

Temperature changes were evident in 2012. *P. montagui* prefer cooler temperatures so the spike in biomass for 2012 in RISA-W may be due to temperatures.

Catch rates for the fishery in the EAZ plateaued below TAC levels in 1999. The exploitation rate has averaged around 9 %. There is a potential downward trend in the average size of shrimp in the area. The estimated biomass is well within the healthy zone of the PA.

A participant asked why the survey catch mean sizes would be higher than fishery catches. The fishery covers different areas from the survey; concentrations are often lower when the size of shrimp is higher.

It was suggested that more recent stock assessment data be used to set LPRs and USRs. This may be required for all SFAs, and the issue has been documented in meetings since 2011.

It was noted that industry uses a factor of 1.6 or 1.7 for effort by double trawls rather than 2.0. This should be reconciled for future work.

Participants had concerns with the use of only three data points for the assessment of P. borealis in the WAZ. The reference points will be updated with current data in future years, but for now these points are the only available. The reference points are required for Marine Stewardship Council (MSC) certification. Similar issues existed for *P. montagui*. Changes with management areas have made estimates challenging.

The question of *P. montagui* being caught in SFA 4 was raised again. Knowing the biomass in this area would suggest this is not a big issue from a biological perspective. This however is a DFO Conservation and Protection (C&P) issue if illegal fishing is occurring and a management issue if an unregulated fishery is occurring in Canadian waters. What catch is reported in Canadian Atlantic Quota Report (CAQR) could be an issue for Science because the assessment of the fishery is based on the reported catches. However Science is not responsible for recording catches.

Participants agreed with the final summary bullets for both species in the both assessment zones included in the SAR.

DISCUSSION OF EXPLOITATION EFFECTS ON SHRIMP PRODUCTION

Author and Presenter: M. Koen- Alonso

The impact of exploitation on shrimp production over all SFAs was explored for lags of 0 to 5 years. Data suggest that a time lag of four years has the highest negative correlation, which seems reasonable since shrimp are fully recruited to the fishery by age 4.

If smaller management areas are used for the analysis the relationship become weaker. This suggests that the spatial scale of the SFAs may not reflect the actual extent and boundaries of the shrimp populations.

The group agreed that scientists and managers need to be aware of the difference between managing a spawning stock within a management area and a stock whose recruitment may end up in a different management area. Further research on this issue was recommended.

Meeting Adjourned.

The next assessment for shrimp in SFAs 2-6 will be completed in 2015, with interim monitoring update report in 2014.

APPENDIX A. TERMS OF REFERENCE

2013 Assessment of Northern and Striped Shrimp
Zonal Peer Review - Newfoundland and Labrador, and Central and Arctic Regions
February 18-20, 2013[1]
St. John's, NL
Chairperson: Bill Brodie

Context

The status of Northern Shrimp (*Pandalus borealis*) in Shrimp Fishing Areas (SFAs) 2 to 6 (NAFO Divisions 0B to 3K) and Striped Shrimp (*Pandalus montagui*) in SFAs 2 and 3 were assessed on a biennial basis through 2010. A Zonal Advisory Process was held in February 2011 due to concerns over the decline of the resource within SFA 6. The assessment was updated in February 2012.

Fisheries Management requested the current assessment as the basis for harvest advice for the 2013/14 fishing season.

Objectives

- Assessment of Northern Shrimp in SFAs 4 to 6 (NAFO Div. 2G to 3K)
- Assessment of Northern and Striped Shrimp in SFAs 2 and 3
- Develop reference points for a Precautionary Approach framework for SFA3 Northern Shrimp and Striped Shrimp
- In the context of the Precautionary Approach advise on the risks and benefits of using a two-year average of spawning stock biomass (SSB), as well as the risks and benefits of using a single year approach to determine the stock status zone. Are there any other methods that could be used to smooth the year-to-year variability? If so, explain the advantages and disadvantages of each method.

Expected Publications

- Two Science Advisory Reports
- Proceedings
- Two Research Documents

Participation

- Fisheries and Oceans Canada (DFO) (Science, and Fisheries Management)
- Newfoundland and Labrador Provincial Department of Fisheries and Aquaculture
- Government of Nunavut
- Nunavut Wildlife Management Board
- Nunavik Marine Region Wildlife Board
- Memorial University
- Fishing Industry
- Other invited experts

[1] February 25-26 will be used to finalize the complete text of the two Science Advisory Reports. All ZAP attendees are invited to participate. Summary bullets for each stock will be agreed upon in plenary during the February 18-20, 2013 meeting.

APPENDIX B. PARTICIPANTS

Name	Association
Ray Andrews	Nunavut Wildlife Management Board
Phil Barnes	Fogo Island Co-op
William Brodie (Chair)	DFO Science, NL Region
Todd Broomfield	Nunatsiavut Government
Ken Budden	Fogo Island Co-op
Brian Burke	Government of Nunavut
Nelson Bussey	Div. 3L Shrimp Vice Chair
Derek Butler	Association of Seafood Producers
Bruce Chapman	Canadian Association of Prawn Producers
Gerard Chidley	Div. 3L Shrimp Chair
Eugene Colbourne	DFO Science, NL Region
Perry Collins	Fogo Island Co-op - 3K Shrimp Fisherman
Estelle Couture	DFO Science, NCR
Peter Crocker	Torngat Fisheries Co-op
Earl Dawe	DFO Science, NL Region
Leigh Edgar	DFO Resource Management, NCR
Geoff Evans	DFO Science, NL Region
Neil Greig	Makivik Corp
Ron Johnson	Torngat Fisheries Co-op
Leon King	DFO NL Region
Len Knight	DFO Resource Management, Area 1E, NL Region
Mariano Koen-Mariano	DFO Science, NL Region
John Lubar	DFO Resource Management, Area 1, NL Region
Gary Maillet	DFO Science, NL Region
Kathleen Martin	DFO Science, C&A Region
Jeff Maurice	Nunavut Tunngavik Inc
Brian McNamara	Newfound Resources Limited
Darrell Mullowney	DFO Science, NL Region
Dave Orr	DFO Science, NL Region
Riley Pollom (Rapporteur)	Centre for Fisheries Ecosystems Research, Fisheries and Marine Institute of Memorial University of Newfoundland
Nancy Pond	NL Department of Fisheries and Aquaculture
Dale Richards	DFO Science, NL Region
Tim Siferd	DFO Science, C&A Region
Bev Sheppard	Harbour Grace Shrimp Co
Lee Sheppard	DFO Science, NL Region

Name	Association
Katherine Skanes	DFO Science, NL Region
Don Stansbury	DFO Science, NL Region
Keith Sullivan	Fish, Food and Allied Workers
Darren Sullivan	DFO Science, NL Region
Ros Walsh	Northern Coalition
Jerry Ward	Baffin Fisheries Coalition
Keith Watts	Torngat Fish Producers Co-opertaive Society Limited
Nadine Wells	DFO Science, NL Region
Julie Whalen	Torngat Wildlife, Plants, and Fisheries Secretariat
Patricia Williams	DFO Resource Management and Aboriginal Fisheries, NL Region

APPENDIX C. AGENDA

Zonal Advisory Process

Northern and Striped Shrimp in SFAs 2, 3, 4, 5, 6

February 18-20, 2013 Holiday Inn, St. John's, NL

February 25-26, 2013 Northwest Atlantic Fisheries Centre St. John's, NL

Chairperson: William Brodie

Monday, February 18

09:00-09:15[2]	Introduction, logistics, review of agenda and schedule	W. Brodie
09:15-09:40	Physical oceanography overview	E. Colbourne
09:40-10:05	Ocean productivity trends	G. Maillet
10:05-10:30	Climate effects on shrimp in SFA 6	E. Colbourne
10:30-10:45	BREAK (coffee/tea provided on all breaks)	
10:45-11:15	Ecosystem considerations	M. Koen- Alonso
11:15-12:00	Averaging of shrimp SSB over multiple assessment years	G. Evans
12:00-13:00	LUNCH (not provided)	
13:00-15:00	Assessment of SFA 6 stock	D. Orr
15:00-15:20	BREAK	
15:20-17:00	Assessment of SFA 6 stock (continued) and drafting of Science Advisory Report (SAR) bullets	D. Orr

Tuesday, February 19

09:00-10:30	Finalization of SAR bullets for SFA 6 Assessment of SFAs 4 and 5 stocks	D. Orr
10:30-10:45	BREAK	
10:45-12:00	Assessment of SFAs 4 and 5 stocks (continued)	D. Orr
12:00-13:00	LUNCH (not provided)	
13:00-15:00	Assessment of SFAs 4 and 5 stocks (continued) and drafting of SAR bullets	D. Orr
15:00-15:20	BREAK	
15:20-17:00	Assessment of SFAs 4 and 5 stocks (continued) and finalization of SAR bullets	D. Orr

[2] Note – all times are tentative. Agenda/schedule may be adjusted based on availability of documentation.

Wednesday, February 20

09:00-10:30	Assessment of SFAs 2 ad 3 stocks	T. Siferd
10:30-10:45	BREAK	
10:45-12:00	Assessments of SFAs 2 and 3 stocks (continued) and Western Assessment Zone Precautionary Approach (PA) reference points	T. Siferd
12:00-13:00	LUNCH (not provided)	
13:00-15:00	Assessments of SFAs 2 and 3 stocks (continued) and drafting of SAR bullets	T. Siferd
15:00-15:20	BREAK	
15:20-17:00	Assessments of SFAs 2 and 3 stocks (continued) and drafting of SAR bullets	T. Siferd

Monday, February 25 (NWAFC)

09:00-17:00 Drafting of SARs (All stock areas)

Tuesday, February 26 (NWAFC)

09:00-17:00 Drafting of SARs (All stock areas)

APPENDIX D. SPEED OF RESPONSE TO CHANGES IN SURVEY RESULTS

In the context of the Precautionary Approach (PA) advise on the risks and benefits of using a two-year average of spawning stock biomass (SSB), as well as the risks and benefits of using a single year approach to determine the stock status zone. Are there any other methods that could be used to smooth the year-to-year variability? If so, explain the advantages and disadvantages of each method.

Immediate Consequences

Before addressing the meat of the question and the thinking behind it, let us deal with some immediate, superficial consequences.

- Changes in survey results are caused in part by changes in the population, in part by changes in the random difference between the survey result and the population.
- With a constant exploitation rate, basing exploitation on a two-year average will not directly affect the catch taken over several years, only the timing of when it is taken. It will have the benefit of subjecting the industry to less-sudden changes.
- If the survey is accurate and the change is in the real population, then the exploitation rate applied will not be the one intended. For example, if the population decreases by 20 % between the two most recent surveys, then an exploitation rate of 16 % of the average of the two surveys will turn out to be 18 % of the actual population. Thus there will be a higher-than intended exploitation of a declining population. If there were a general tendency for stock changes to persist in the same direction for several consecutive years, averaging in a declining population would produce an exploitation rate systematically higher than the nominal rate.
- There is an intuition that at large stock size a response spread over two years would not cause problems; but it is unknown at what stock size problems might start to arise.

Examining the Question

It is reasonable to assume that the people who inserted the term of reference were well aware of all the immediate consequences described above, and what they really wanted to know is: Do they, or when do they, matter? In the context of the PA, when do the immediate consequences of two-year averaging cause problems or concerns? But at this point it is well to consider the words of Northrop Frye: "To answer a question is to consolidate the mental level on which the question is asked." It draws attention away from "the possibility of better and fuller questions." Perhaps we should frame the question not in terms of a gadget proposed as a solution, but in terms of the underlying desires and concepts: How should one respond to fluctuations in the resource (construed either narrowly, to mean what is harvested, or broadly, to include what contributes to what is harvested)? How should fluctuations be apportioned between the resource and the industry, and how does the answer change with changing circumstances?

It is worth recognizing that an answer can have two different types of merit: pragmatic and principled. Pragmatic merits include being familiar and easy to grasp and implement, having comfortable intuitive properties (for example being more cautious when the stock is low), making large buyers more willing to buy the product. Principled merits are based on having the underlying science right, so that the strategies are likely to have the desired effect on the resource.

Unpacking the Question

To give a proper answer to that question, we need to examine its component parts. Given the way the ecological production system works, given what we value about it, given a range of possible interventions, what is the best (or a good) management strategy to adopt? One question then becomes many.

Science Questions

- How to delimit the stock, or the ecosystem of which it is a part (the 'resource' for short), in both ecological and geographical space.
- What is the current state of the resource, and its recent history?
- What rules describe how it can change? To what extent do they have fluctuating or random components?
- What are the probable external influences across its ecological and geographic boundaries?
- What are the properties, especially potential errors, of the techniques used to measure it? How accurately can one estimate the numerical parameters that form part of the rules?

Value Questions

- What elements of the resource do we value, and how do we assess their value?
- What is the discount rate for values in the future?
- What risks are we prepared to tolerate?

Management Questions

- What management options are available? (For example, basing exploitation rate on a two-year average of surveys.)
- What is their expected effect on the value of the resource?
- How easy are they to understand, implement and gain compliance with?

Summary Questions:

- Integrating answers to all the above questions, how would one demonstrate that a proposed answer or procedure is appropriate?
- How would one evaluate and rank different management options?
- A summary question to which the Terms of Reference (ToR) describes on candidate answer: There will be high-frequency (year-to-year) variation in the stock survey estimate. It is inconvenient for the fishing industry to cope with large year-to-year variation in its quota. In what circumstances can it be safe to maintain a low variability in fishing removals, thereby imposing more of the variability (if there is any, if it's not just survey noise) on the resource?

Punt

It seems clear that anything less than a proper management strategy evaluation would be only a superficial answer to the underlying question we were presented with. The assessment meeting had neither the time nor the collective expertise to provide a proper answer.

We recognize, and are sensitive to, the gap between decisions Management is called on to make and questions Science is comfortable answering. The ToR was phrased "in the context of the Precautionary Approach", and it is reasonable to suppose that the PA framework was developed in part to bridge this gap; that it contains explicit (if simplified) assumptions about the answers to the Science and Management questions posed above. If this is the case, any consideration of the ToR would benefit from knowing what they are. Failing that, it should at least be possible to do an inverse analysis: In what plausible world, represented by a set of answers to the Science and Management questions, is the current PA framework an appropriate response, the best choice within the space of available responses? If DFO cannot answer that question, we would have to conclude that there is no plausible world in which the PA framework made scientific and economic sense, which would be embarrassing.

Any reputable framework will include a process for detecting and correcting mistakes and inadequacies.

Some decisions that have to be made:

- The implicit background to the ToR question includes the assumption that variations in survey results are to be expected and some of them will be because of variations in the underlying stock. Perhaps we don't need to know what causes such variations, but we must at least know what characteristics they have: how large, how correlated between successive years?
- Was the current PA framework (its underlying goals, the quantity to be optimized) developed envisaging such variations? If not, does it need revising now that variation has been introduced?
- Is SSB an appropriate measure of the state of the resource? Is there *any* suitable measure that can be expressed as a single number? The problem is that shrimp (female) SSB takes no account of shrimp that are already alive but not yet female. If there were a total absence of these, our intuition would be to regard this as a critical problem regardless of the size of SSB.

Et Cetera

The meeting concluded that the ToR might also have meant how to identify, and correct for, survey noise in the most recent year. Although some tentative approaches to this question were identified, they were not especially promising and nobody proposed to work on them or was eager to have work done on them. Besides, bundling together two totally different questions, simply because the same answer (two-year average) had been thought of for both of them, makes little sense.